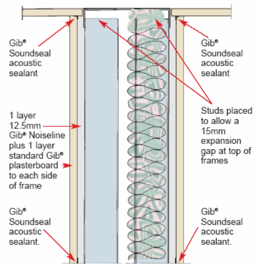
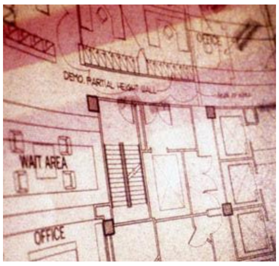
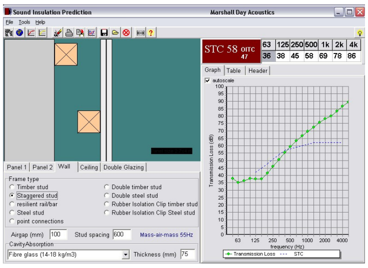
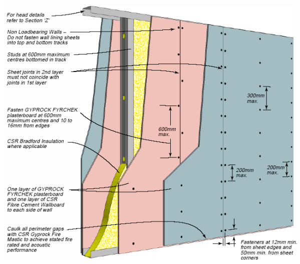


PREDICTING SOUND INSULATION PERFORMANCE

USING SOUND INSULATION SOFTWARE TO PREDICT NON-ACHIEVEMENT OF PERFORMANCE STANDARDS (CRITERIA). PRESENTED AT THE NEW ZEALAND ACOUSTICAL SOCIETY CONFERENCE 2002

INTRODUCTION

A quick and simple method to assist in determining why inter-tenancy partitions and floor/ceiling assemblies do not achieve performance standards is discussed below. Usually, following on-site measurements to determine compliance it is often the case that when non-achievement of the performance standards occurs the reasons for this needs to be investigated to determine appropriate remedial treatment. The use of Sound Insulation Prediction Software (SIPS), such as INSUL, to predict non-achievement of performance standards (criteria) is one method of achieving this. This prediction software also supplements other methods which are sometimes time and equipment consuming, e.g. vibration measurements, intensity measurements, and the more destructive methods of demolishing constructions to determine failures. Sometimes the experienced acoustician can help determine certain failures by on-site observation, but this is a rare gift, requires a considerable knowledge database and good hearing.

The various inter-tenancy (IT) wall and floor/ceiling combinations which do not achieve minimum performance criterion are usually related to non-conformance with manufacturer's/suppliers materials or specifications, or deviations from standard acoustic treatment that minimises the potential for flanking noise transmission paths. The design criterion may be that based on the New Zealand Building Code or some other specific criterion which is development site specific.

SIPS, although rare, is a very useful tool to quickly evaluate new materials and systems, or to investigate the effects of changes to existing designs. This paper shows that SIPS can also be used to help predict non-achievement of performance standards when used in conjunction with on-site measured sound insulation performance data, construction information and details.

PREDICTION SOFTWARE

INSUL (www.insul.co.nz) is a programme for predicting the sound insulation performance of walls, floors, ceilings and windows. It is based on simple theoretical models that require only limited construction information. The programme can make reasonable predictions of the transmission loss (TL) and weighted sound reduction index (R_w) for use in noise transfer calculations.

INSUL can be used to quickly evaluate new materials and systems or to investigate the effects of changes to existing designs. It models materials using the simple mass law and coincidence frequency approach and models more complex partitions using work by Sharp, Cremer, and others. It has evolved over several versions into an easy to use tool that takes advantage of the Windows™ environment, and has refined the theoretical models by continued comparison with laboratory tests to provide acceptable accuracy for a wide range of constructions.

Like any prediction tool the sound insulation software is not a substitute for measurement. However, comparisons with test data show that INSUL is generally within three STC points for most constructions and, as will be seen below, is within one STC point for the majority of constructions reviewed in this paper.

INTER-TENANCY WALL AND FLOOR/ CEILING SYSTEMS REVIEWED

The following case studies of constructions concerning IT walls and floor/ceiling assemblies are reviewed where they have not achieved performance standards determined by the New Zealand Building Code, Clause G6, or for development sites that specify criteria of a higher standard than the Building Code. The non-achievement of performance standards (criteria) reviewed is due to a number of items including:

- non-installation of construction materials as specified by the manufacturer/supplier;
- deviation from the specified manufacturer's or suppliers materials;
- deviation from typical manufacturer's/supplier's detailing of constructions for their IT walls and floor/ceiling assemblies;
- flanking noise transmission paths which would not normally be considered in typical apartment constructions.

The IT wall and floor/ceiling assemblies that have failed to meet the performance standards, which SIPS is used to assist with failure analysis with, include the following:

1. A single stud resilient rail wall (Gib GBT(L)A 90r, STC 55) where the cavity insulation was not installed.
2. A single stud timber wall with resilient rail (Gib GBT(L)A 60, STC 55) where a non-conforming resilient rail was used.
3. A single steel stud wall (Elephant Plasterboard EBSA60b, STC 56) that exhibits a failure, although minor, due to lack of resilient rail.
4. A single timber stud wall (CTS Type TGTLA 60p, STC 55) where linings are fixed through polyester strip.
5. A steel stud resilient rail wall (Gib GBSA 60A, STC 55) which failed due to continuous flooring membrane.
6. Double timber stud wall (with predicted rating of STC 65) that failed due to continuous (thin) concrete floor.
7. Double steel stud wall (Elephant Plasterboard EBSA60B, STC 66) that failed due to common timber top plate.
8. A timber floor and ceiling construction (Gib GBSCA 60a, STC 58) that failed due to the incorrect resilient suspension system being installed.

The above constructions are discussed in detail overleaf.

1. Single Stud Resilient Rail Wall – Cavity Insulation Failure

A Winstone Gib GBT(L)A 90r STC 55 wall (refer Table 1) was specified for the IT walls in an apartment complex. However, when on-site compliance measurements were carried out the results were typically FSTC 45, as shown in Figure 1A.

SIPS was used to predict the performance for this wall construction, without cavity insulation. A prediction of STC 47 and the shape of the transmission loss (TL) curve closely approximate that of the on-site failure curve (refer Figure 1A).

The wall was re-built with cavity insulation and retested. Figure 1B shows the SIPS predicted rating for the specified wall construction, STC 56, and the re-measured wall results (FSTC 55) following inclusion of cavity insulation. Close observation during re-build, and masonry floors helped to minimise flanking paths and result in a satisfactory on-site sound insulation performance.

Figure 1A: Single Stud Resilient Rail Wall
Gib GBT(L)A 90r - STC 55
Cavity Insulation Failure

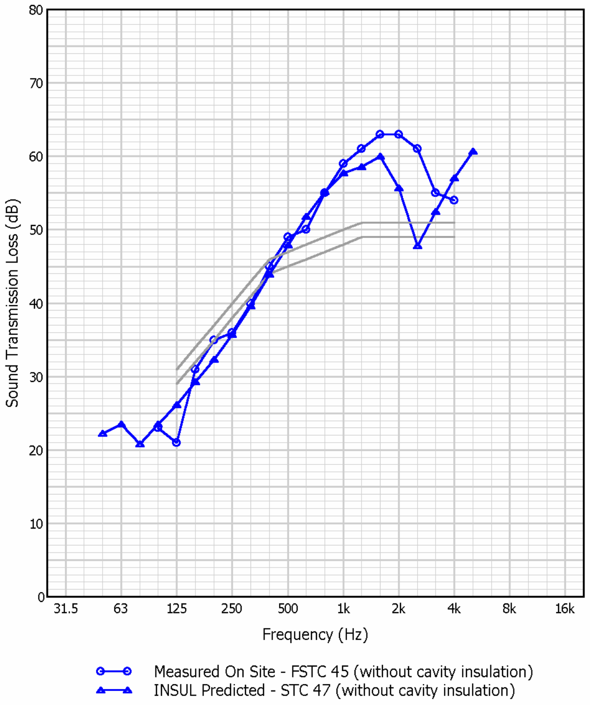
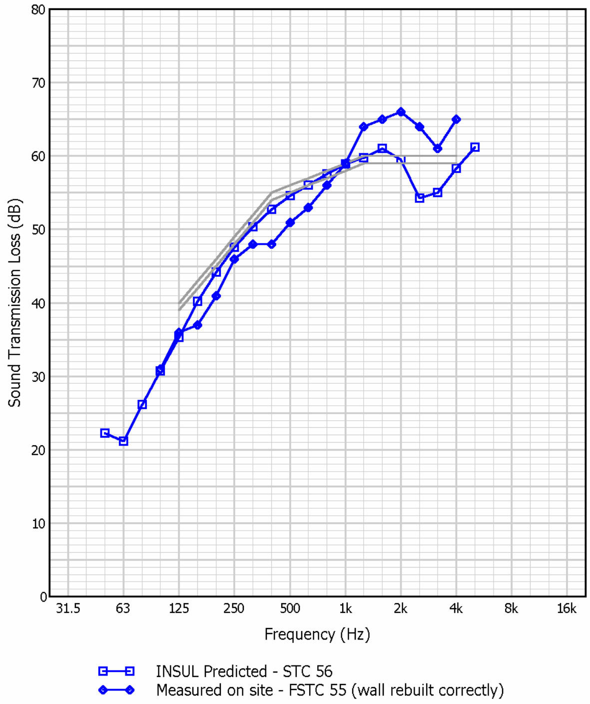


Figure 1B: Single Stud Resilient Rail Wall
Gib GBT(L)A 90r - STC 55
Cavity Insulation Included



2. Single Timber Stud Resilient Rail Wall – Incorrect Resilient Rail Failure

A Winstone Gib GBT(L)A 60a (refer Table 1) with measured performance of STC 55, was specified for an apartment project which however resulted in on-site failure due to substitution of a non-conforming resilient rail.

In Figure 2A, the measured on-site performance of two walls are shown with a measured sound insulation performance of FSTC 47. This rating falls short of the minimum NZ Building Code criterion (FSTC 50). Also, shown in Figure 2A is the SIPS prediction (STC 48) for the same wall construction without a resilient rail. The shape of the on-site and predicted TL curves closely approximate each other between 100 and 2,000 Hz.

The walls were rebuilt with the correct resilient rail installed and follow up measurements confirmed that the NZ Building Code criterion was met (i.e. FSTC 50 measured on-site). Figure 2B shows these results including the SIPS sound insulation performance rating (STC 56) of the wall. The prediction and on-site performance TL curves closely approximate each other when allowing for on-site losses due to flanking and construction techniques.

Figure 2A: Single Stud Resilient Rail Wall
Gib GBT(L)A 60 - STC 55
Incorrect Resilient Rail Failure

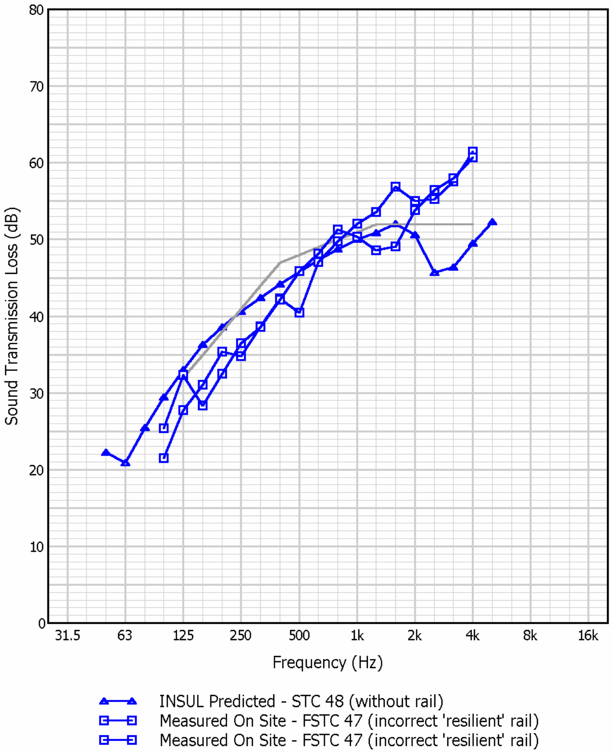
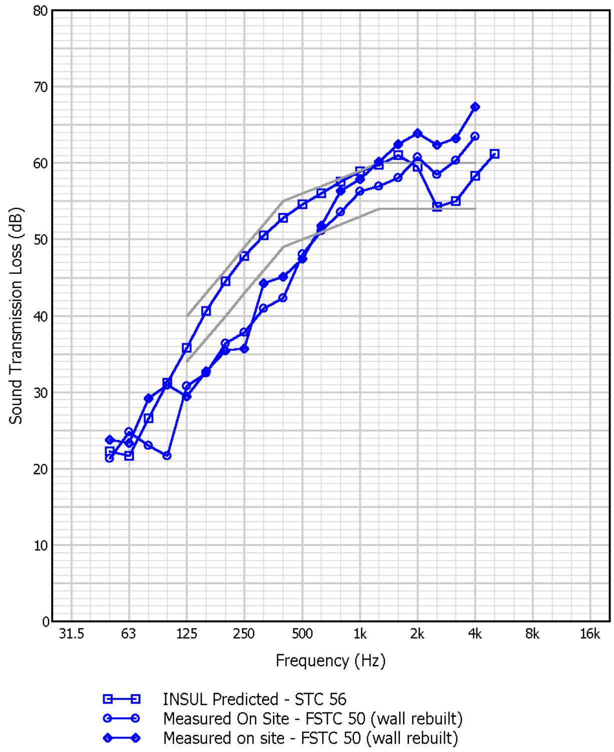


Figure 2B: Single Stud Resilient Rail Wall
Gib GBT(L)A 60 - STC 55
Correct Resilient Rail Used



3. Single Steel Stud Wall – General Failure

For this particular apartment complex Elephant Plasterboards EPSA60b with a measured performance of STC 56 were used for the construction of the IT walls (refer Table 1). On-site measurements revealed performances of typically FSTC 49.

The measured on-site results are shown for two walls in Figure 3A. The measured on-site result is also repeated in Figure 3B along with the SIPS rating for this construction, STC 55. A possible solution to meet the NZ Building Code is the provision of an additional sheet to one side of the partition on-site (SIPS predicted STC 58).

From a number of tests of single stud partitions, both within the laboratory and on-site, allowing for the vagaries of flanking transmission and construction techniques indicates that resilient rails are required on single stud walls in order to meet the minimum criterion. SIPS also predict STC 55 for this Elephant Plasterboard wall construction. However the SIPS is a prediction tool and, as noted above, complying and maintaining the on-site minimum performance criterion is very difficult without the inclusion of resilient rails. The frequency range in which the resilient rail is performing in conjunction with a single stud wall is clearly shown in Figure 4A and corresponds to the test frequency range for on-site testing.

Figure 3A: Single Steel Stud Wall
EP EBSA60b - STC 56
FSTC Failure

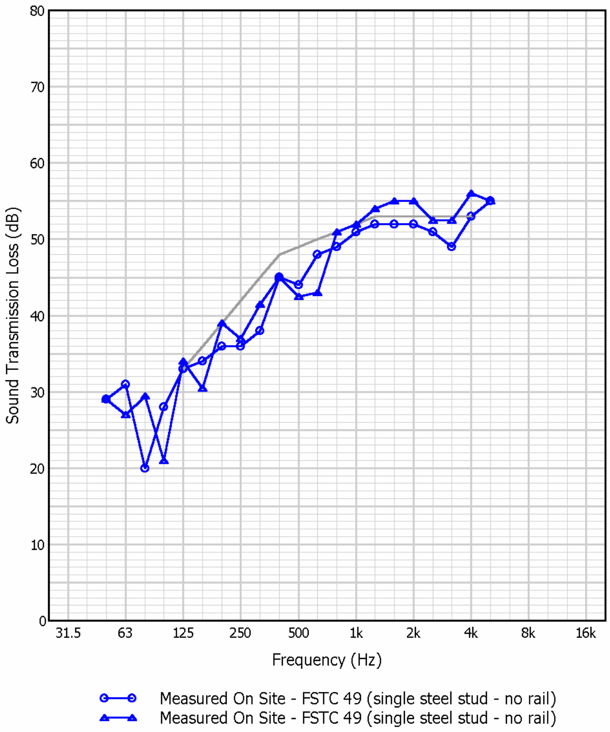
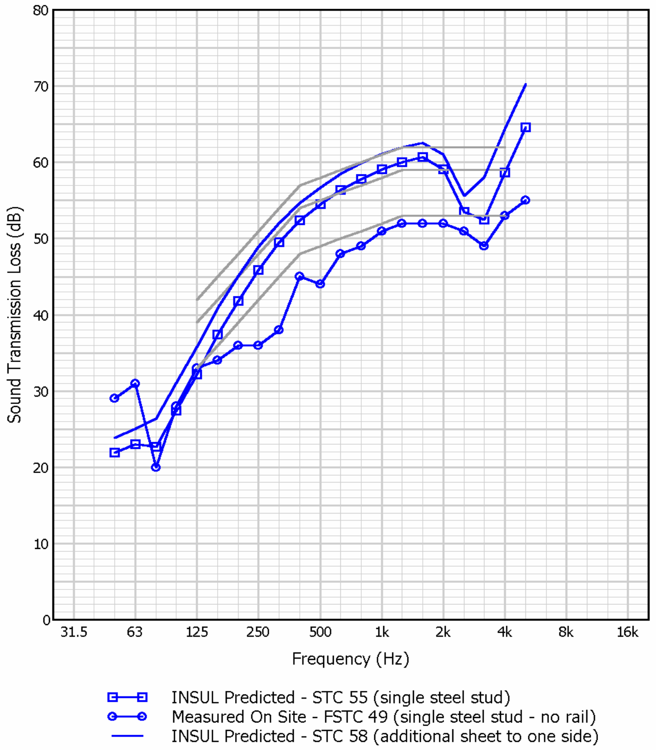


Figure 3B: Single Steel Stud Wall
EP EBSA60b - STC 56
Predicted & Measured On Site



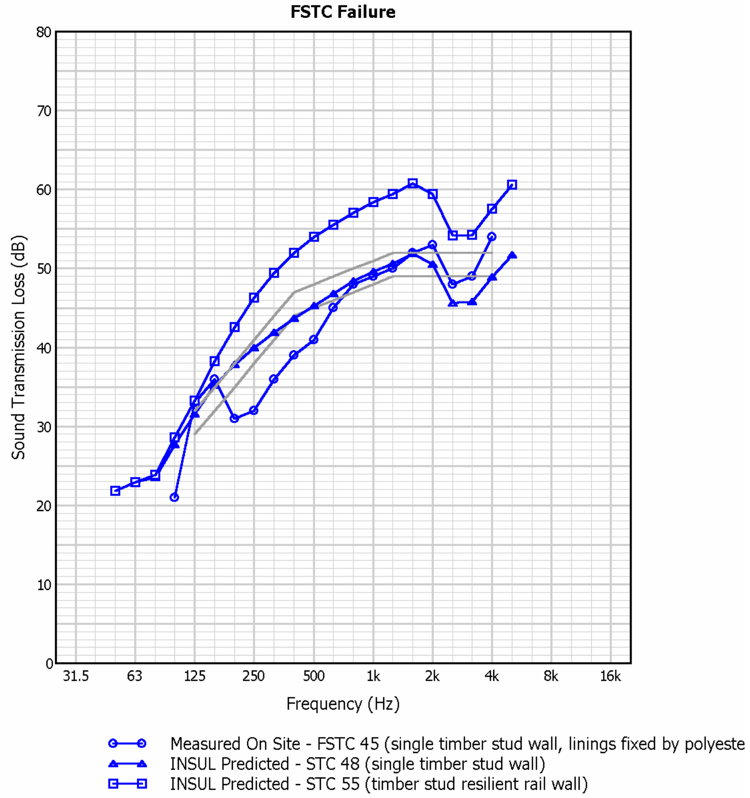
4. Single Timber Stud Wall – Failure Through Non-Resilient Lining Fixings.

For this apartment complex the builder had recommended as an alternative to the specified resilient rail STC 55 wall the use of a CTS Plasterboard Products type TGLA60p wall construction which has a documented rating of STC 55. As described in Table 1 the wall linings are connected to the studs through Polyester strips.

The measured on-site performance of FSTC 45 for this wall construction is shown in Figure 4A. Also, in Figure 4A is the SIPS rating for this wall of STC 48 based on the wall linings directly fixed to the timber stud. There is very close agreement between the predicted and on-site TL's, except for a notable reduction around 250 Hz for the on-site performance, most likely due to some form of resonance.

The same wall construction with resilient rails replacing the polyester strips is shown in Figure 4A with a predicted rating of STC 55. For this apartment complex the originally specified walls with resilient rails were installed.

Figure 4A: Single Timber Stud Wall - Linings Fixed Through Polyester Strip
CTS TGTLA60p - STC 55
FSTC Failure



5. Steel Stud Resilient Rail Wall – Continuous Floor Failure

In New Zealand there are a large number of buildings that are being refurbished where the floors, typically timber, are being maintained and refurbished. The inherent problem of continuous floors on the sound insulation performance of wall systems is well known and documented, and despite this a number of apartments are still being constructed on continuous floors. On a recent project a Winstone Gib GBSA60 wall (refer Table 1 and Figure 5A) with a measured performance of STC 55 was installed in a refurbished apartment building.

The measured on-site results as described in Figure 5A, revealed significant non-compliance with the NZ Building Code criterion where results of FSTC 42 and FSTC 43 were obtained. The shape of the on-site sound transmission loss curve indicated a significant dip in the curve occurring at 400 Hz. The existing flooring, a 35 mm thick tongue and groove timber was modelled in the SIPS and its TL curve is also shown in Figure 5A. The coincidence dip for this flooring system coincided with those for the measured results on-site.

Following rectification works, where a saw cut was placed in the timber floor directly below the resilient rail, and in accordance with typical Winstone junction details, the wall was re-measured and an on-site performance of FSTC 51 was achieved. The results of this test and the SIPS performance of STC 55 for the Gib GBSA 60a wall are shown in Figure 5B.

Figure 5A: Steel Stud Resilient Rail Wall
Gib GBSA60a - STC 55
FSTC Failure Due To Continuous Floor

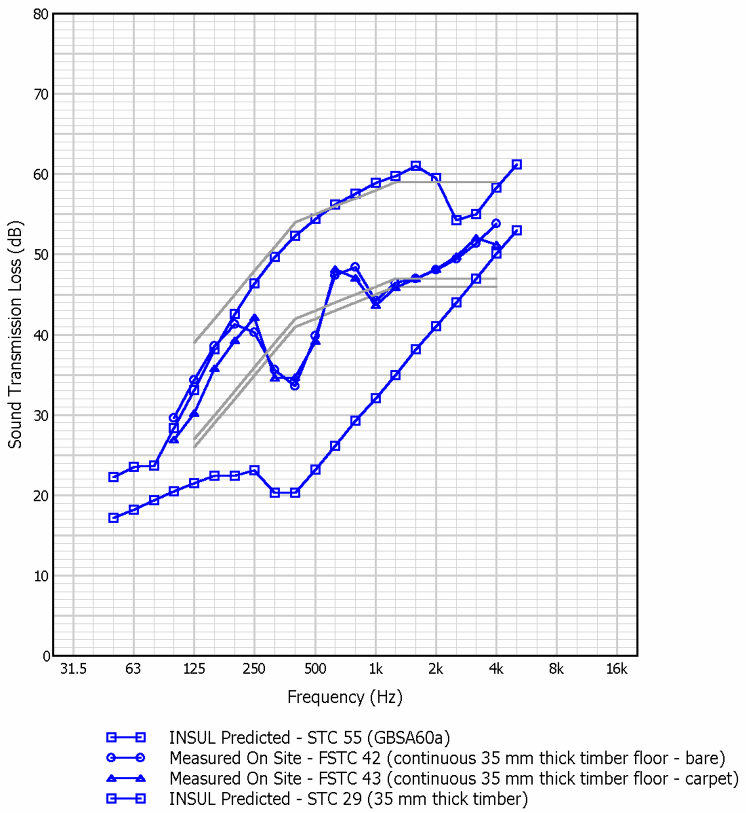
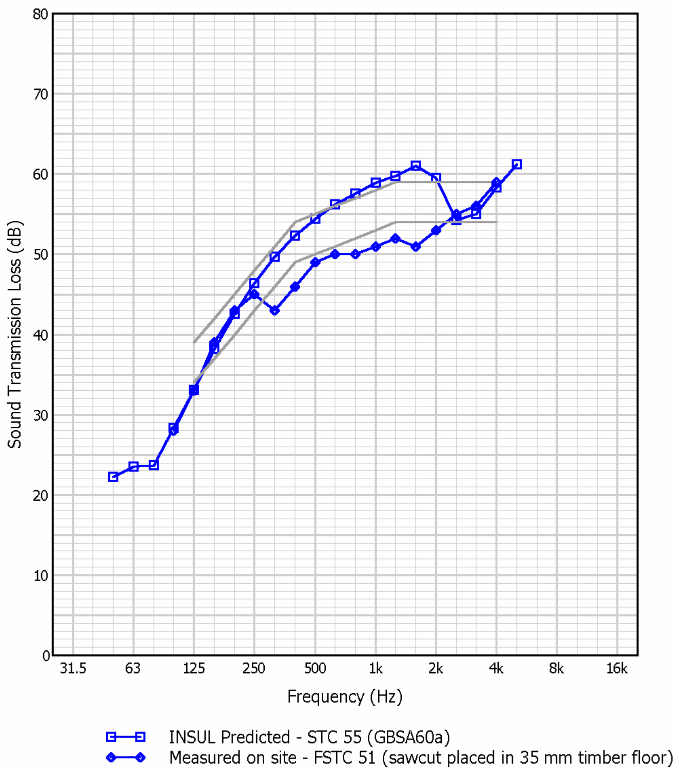


Figure 5B: Steel Stud Resilient Rail Wall
Gib GBSA60a - STC 55
Timber Floor with 'Sawcut'



6. Double Timber Stud Wall – Continuous Concrete Floor Failure

A wall similar to Winstone Gib GBT(L)A 30b was specified and constructed in an apartment block where higher criteria than that proposed in the NZ Building Code was specified. The wall construction was similar to that of the Winstone Gib GBT(L)A 30b (refer Table 1) with an additional layer of 13 mm Gib Toughline attached to the side with one layer of 10 mm Noiseline. The measured performance of the above Winstone double timber stud wall is STC 58 and with the additional layer of 13 mm Gib Toughline the SIPS rating is STC 65 as described and shown in Figures 6A and 6B.

Following on-site compliance testing of the above wall constructions, several walls indicated very poor performances of typically FSTC 48, when on-site results of FSTC 58 or better were expected.

There is a propensity in New Zealand to use thin structural slab floor systems such as Stahlton concrete floors and Dycore with 'hit and miss' infills, to reduce building costs. With respect to vertical noise separation these types of flooring systems have potential acoustic sound insulation and impact deficiencies that need to be designed for. They can also have detrimental horizontal flanking performances as is described below.

In the case of an apartment complex a Stahlton flooring system was used where, between concrete beams or ribs, timber support infill panels were used on which a concrete topping was poured. In some cases this concrete topping can be quite thin (e.g. 60 to 75 mm thick). Figure 6A shows the SIPS predicted performance for a 60 mm thick concrete floor which has a noticeable coincidence dip in its sound transmission loss at 630 Hz. The shape of 60 mm thick concrete floor sound transmission loss curve below and above this coincidence frequency dip closely approximates that of the measured on-site performance of the failed wall system. Follow up vibration measurements on the floor, wall and adjacent perimeter walls and ceiling confirmed that the concrete floor was the controlling noise transmission path in this instance. Figure 6B describes the results for the same wall construction that was located over a concrete beam, which achieved a rating of FSTC 56. The sound transmission loss curve for this on-site result above 250 Hz appears to follow the SIPS performance curve for the wall construction. Also shown in Figure 6B is the SIPS predicted rating of STC 52 for a 125 mm thick concrete floor and, again, this appears to closely approximate that TL curve for the on-site FSTC 56 floor.

Figure 6A: Double Timber Stud
INSUL Predicted - STC 65 Wall
FSTC Failure Due To Continuous Concrete Floor

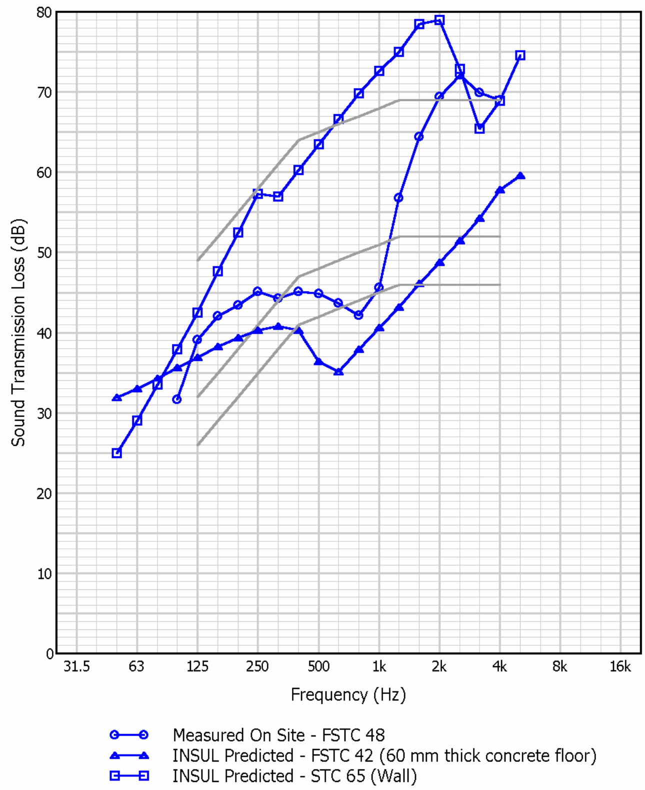
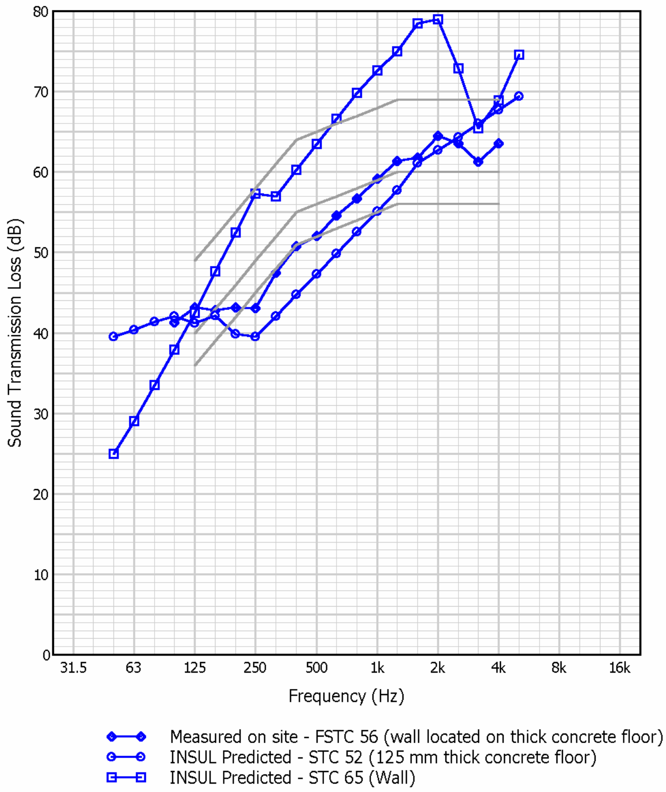


Figure 6B: Double Timber Stud
INSUL Predicted - STC 65 Wall
Wall FSTC Pass



7. Double Steel Stud Wall – Common Timber Top Plate Failure

To achieve an FSTC 58 performance in an apartment project the client specified a wall with a rating of at least STC 65. The builder for this project proposed an Elephant Plasterboard EBSA60b STC 66 rated wall as described in Table 1. The SIPS prediction for this wall construction is STC 66 and is described in Figure 7A. The first wall construction was tested on-site and a favourable measured result of FSTC 60 was obtained as described in Figure 7A.

As the building works progressed further on-site tests were carried out and typical results of around FSTC 53 to 54 were obtained and are described in Figure 7B. The SIPS predicted rating for this modelled wall, FSTC 54, is also shown in Figure 7B. The construction modelled is based on the double steel stud wall being connected by a common timber top plate (i.e. a 150 x 25 mm timber plate that was in turn directly fixed to a major steel beam). The sound transmission loss curves for the on-site measured levels and the SIPS predictions appear to mirror each other throughout the test spectrum range except for a slight octave difference in the coincidence frequencies. Another on-site measurement (FSTC 52) of a wall which had a common top plate and some high frequency leakage is shown in Figure 7C. Following a rebuild of this wall, which involved the separation of the common timber plate and sealing the wall perimeter, a very satisfactory on-site result of FSTC 59 was achieved. These results are described in Figure 7C.

Figure 7A: Double Steel Stud
EP EBSA60b - STC 66
INSUL Predicted and Initial On Site Test

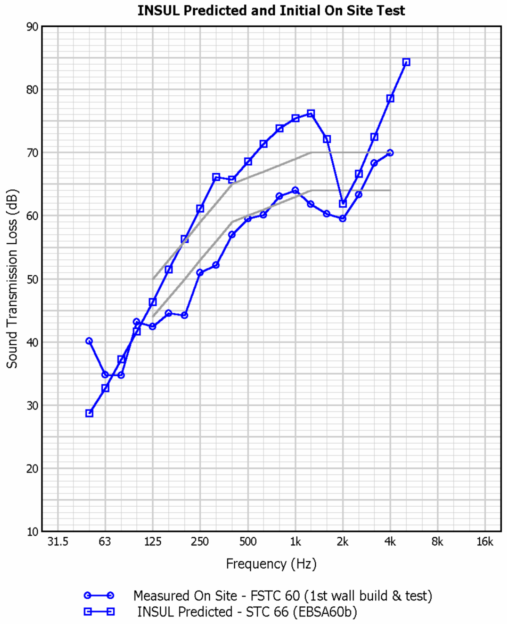


Figure 7B: Double Steel Stud
EP EBSA60b - STC 66
FSTC Failure Due To Common Timber Top Plate

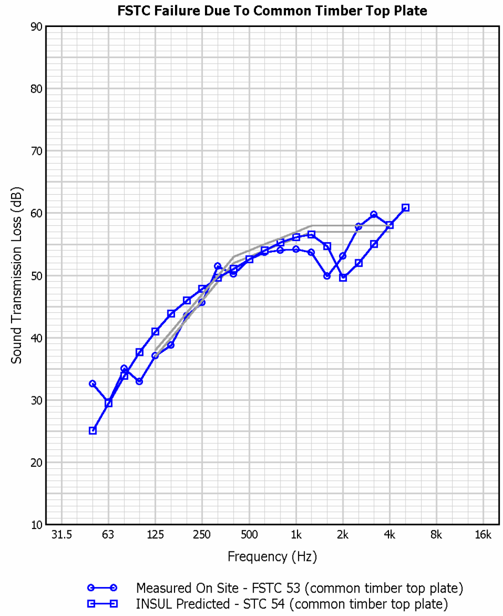
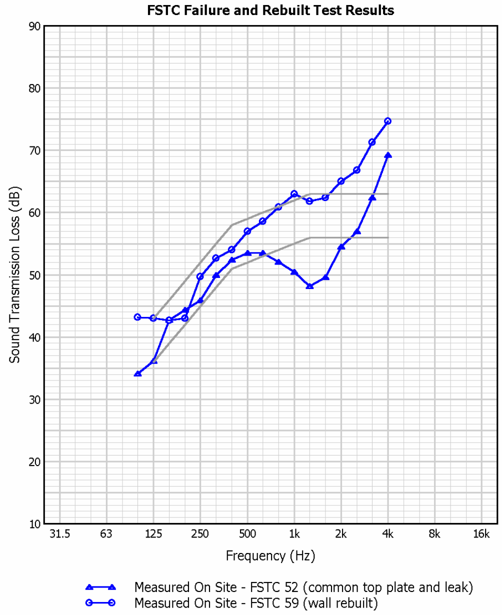


Figure 7C: Double Steel Stud
EP EBSA60b - STC 66
FSTC Failure and Rebuilt Test Results



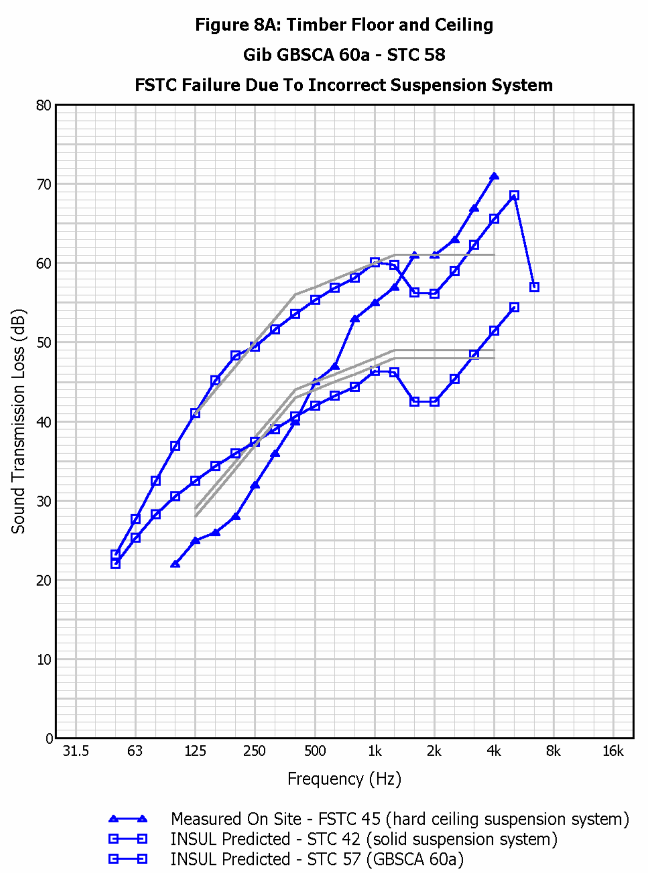
8. Timber Floor and Ceiling Assembly – Incorrect Suspension System Failure

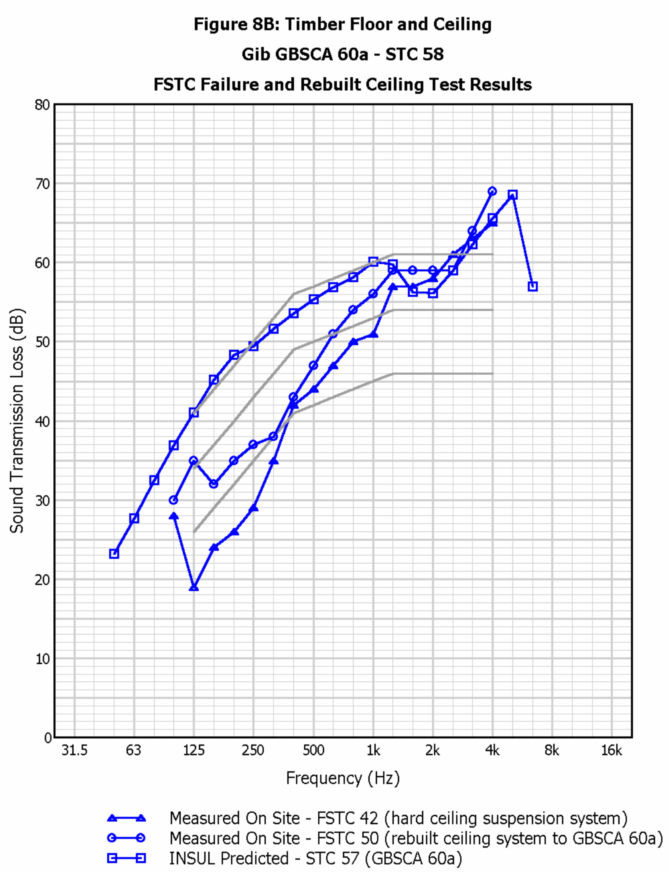
On a project where a Winstone Gib GBSCA 60a timber floor and ceiling system was specified (refer Table 1), the on-site results indicated a major failure of the construction.

The on-site result of FSTC 45 revealed a significant problem and non-conformance with the minimum Building Code criterion. The results are described in Figure 8A, including those for the SIPS prediction of the wall performance. Also shown in Figure 8A is the prediction of the same wall with the ceiling linings hard connected to the floor joists. The SIPS prediction is not as satisfactory as one would like and can be explained by the fact that:

- the ceiling suspension system used is not an equivalent or equal to that recommended by Gib, and,
- there is a major resonance effect occurring below 400 Hz which at this stage cannot be modelled by the SIPS.

The results of another floor/ceiling system in the building is also shown in Figure 8B, before and after rectification works, which showed an improvement from FSTC 42 to FSTC 50 following installation of the correct resilient suspension system as specified by Gib.





Discussion

A sound insulation prediction method to determine, quickly and simply, the reasons why various constructions do not achieve performance standards on-site is introduced, discussed and tested. The SIPS (INSUL) described and used to predict and model several on-site failures is found to accurately assist in the prediction of why non-compliance of criteria has occurred. Within the predicted transmission loss curves for some IT walls and floor/ceilings constructions reviewed there are resonance 'dips' related to the non-conforming construction elements used, that are not accurately depicted by the SIPS. With the addition of further empirical and theoretical analysis of these elements the SIPS will be a powerful modelling and prediction tool.

(Paper written by Peter Heinze, Marshall Day Acoustics, P O Box 5811, Wellesley Street, Auckland)

Table 1: IT Wall and Floor/Ceiling Details

System and Figure	Supplier's Reference	Construction			STC Rating	
		Side 1	Frame & Insulation	Side 2	Lab	SIPS
1 Figs 1A, B	GBT(L)A 90r Gib	2 x 13 mm Gib Fyreline	Timber -- 90 mm x 45 mm, R1.8	2 x 13 mm Gib Fyre-line, Resilient Rail	STC 55	STC 56
2 Figs 2A, B	GBT(L)A 60a Gib	2 x 13 mm Gib Fyreline	Timber -- 100 mm x 50 mm, R1.8	2 x 13 mm Gib Fyre-line, Resilient Rail	STC 55	STC56
3 Figs 3A, B	EPSA60b Elephant Plaster-board	2 x 12 mm Standard	Steel –76 mm IBS, R1.8	2 x 12 mm Standard	STC 56	STC 55
4 Fig 4A	CTS Plasterboard Products	1 x 13 mm TG Standard 1 x 13 mm TG Fyrestop	Timber -- 90 mm x 45 mm, R1.8 Polyester Strip to face of studs	1 x 13 mm TG Standard 1 x 13 mm TG Fyrestop	STC 55	STC 48
5 Figs 5A, B	GBSA60 Gib	2 x 13 mm Gib Fyreline	Steel – 64 mm x 35 mm, R1.8	2 x 13 mm Gib Fyre-line, Resilient Rail	STC 55	STC 55
6 Figs 6A, B	GBT(L)A 30b Gib + Additional Toughline	2 x 10 mm Noiseline	Double Timber -- 90 mm x 45 mm with 25 mm gap, R1.8	1 x 10 mm Noiseline, 1 x 13 mm Tough-line		STC 65
7 Figs 7A, B, C	EBSA60b Elephant Plaster-board	2 x 15 mm Elephant Plasterboard	Double Steel – 76 mm IBS with 10 mm gap, R1.8	2 x 15 mm Elephant Plasterboard	STC 66	STC 66
8 Figs 8A, B	GBSCA 60a Gib	20 mm flooring grade particle board	200 mm x 50 mm joists at 450 centres, R1.8, Gib suspension system	1 x 16 mm Gib Fyreline, 1 x13 mm Gib Fyreline	STC 58	STC 57